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**A Preliminary Investigation of the Helminth
Parasites of Flying Squid, (*Ommastrephes
bartrami*), in Northeastern Pacific Waters and
Comparison With Other Parasite Surveys of
Ommastrephidae**

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HELMINTH PARASITES OF FLYING SQUID, Ommastrephes bartrami, IN
NORTHEASTERN PACIFIC WATERS AND COMPARISON WITH
OTHER PARASITE SURVEYS OF OMMASTREPHIDAE

by

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ABSTRACT

Bower, S.M., Margolis, L., and Yang, D.T.C. 1990. A preliminary investigation of the helminth parasites of flying squid, Ommastrephes bartrami, in northeastern Pacific waters and comparison with other parasite surveys of Ommastrephidae. Can. Tech. Rep. Fish. Aquat. Sci. 1750: 19 p.

Helminths were observed in all 68 flying squid, Ommastrephes bartrami (females with mean mantle length of 38.7 ± 3.6 cm and total mean wet weight of 2.1 ± 0.7 kg), examined from five drift gillnet sets off the west coast of North America in the summer of 1987 between $41^{\circ}03'$ and $48^{\circ}23'$ N latitude and $129^{\circ}49'$ and $133^{\circ}08'$ W longitude. All flying squid were infected with 10 to 166 juvenile Hysterothylacium sp. (Nematoda) that were mainly of small size (about 6 mm in length) and located within capsules on the stomach wall (average of 3.3 ± 1.4 specimens per capsule). Approximately 2% of all Hysterothylacium sp. ranged from about 20 mm to 35 mm in length and were encapsulated in the mantle or free on the surface of the gills. Eleven Anisakis simplex larvae were encapsulated on the visceral tissues of nine of the flying squid. Metacestodes of Phyllobothrium sp. were recovered from 94.1% of the squid (1 - 121 specimens per squid) and one metacestode of Tentacularia sp. (probably I. coryphaenae) was found in the sample bag that held one flying squid. The only adult helminths recovered were seven Rhadinorhynchus sp. (Acanthocephala) from the stomach and pyloric caecum of three squid. The parasite fauna of these squid was different from that previously reported for O. bartrami from other oceans occupied by this circumpolar species and was different from records from other species of the family Ommastrephidae from the Pacific Ocean.

RÉSUMÉ

Bower, S.M., Margolis, L., and Yang, D.T.C. 1990. A preliminary investigation of the helminth parasites of flying squid, Ommastrephes bartrami, in northeastern Pacific waters and comparison with other parasite surveys of Ommastrephidae. Can. Tech. Rep. Fish. Aquat. Sci. 1750: 19 p.

Des helminthes ont été observés chez les 68 calmars, omastrephes bartrami, (femelles avec une longueur moyenne du manteau de $38,7 \pm 3,6$ cm et un poids frais moyen total de $2,1 \pm 0,7$ kg), provenant de cinq jeux de filets maillants dérivants mouillés au large de la côte ouest de l'Amérique du Nord, au cours de l'été 1987, entre $41^{\circ}03'$ et $48^{\circ}23'N$ de latitude et $129^{\circ}49'$ et $133^{\circ}08' W$ de longitude. Tous les calmars contenaient de 10 à 166 juvéniles de Hysterothylacium sp. (Nématodes), surtout de petite taille (6 mm de longueur environ) se trouvant dans des capsules sur la paroi stomacale (une moyenne de $3,3 \pm 1,4$ spécimens par capsule). Environ 2% de tous les Hysterothylacium sp. mesuraient entre 20 mm et 35 mm environ et ils étaient encapsulés dans la manteau ou libres à la surface des branchies. Onze larves de Anisakis simplex étaient encapsulées dans le tissu viscéral de neuf calmars. Des larves enkystées (métacestode) de Phyllobothrium sp. ont été retrouvées chez 94,1 % des calmars (1-121 spécimens par calmar) et un métacestode de Tentacularea sp. (probablement T. coryphaenae) a été trouvé dans le sac d'échantillonnage contenant l'un des calmars. Les seuls helminthes adultes récupérés étaient sept Rhadinorhynchus sp. (Acanthocephala) provenant de l'estomac et du caecum pylorique de trois calmars. La faune parasitaire de ces calmars différait de celle qui avait déjà été signalée chez O. bartrami provenant d'autres océans occupées par cette espèce circumpolaire et était différente des mentions d'autres espèces de la famille Ommastrephidae de l'océan Pacifique.

INTRODUCTION

The helminth parasites of many species of cephalopods, including members of the family Ommastrephidae, have been documented (Hochberg 1983; Gaevskaya and Nigmatullin 1983). One species of flying squid, Ommastrephes bartrami, has recently acquired major commercial importance in the North Pacific Ocean (Jamieson and Heritage 1988). This species has a discontinuous (bisubtropical) global distribution (Shevtsova et al. 1979). The helminth fauna of O. bartrami from the Atlantic, Indian, and southeastern and northwestern Pacific oceans has been surveyed (Filippova 1974; Gaevskaya 1974, 1976; Gaevskaya and Nigmatullin 1976, 1977, 1978; Belyaeva 1979; Bagrov 1982; Kurochkin and Solov'eva 1982; Gaevskaya et al 1983, 1986; Shukhgalter 1986; Shukhgalter and Polezhaev 1987). However, prior to our study, no information was available on parasites of O. bartrami from the eastern North Pacific Ocean.

Experimental fishing for O. bartrami conducted off the coast of North America in 1987 (Jamieson and Heritage 1988) presented the opportunity to examine specimens from the northeastern region of the North Pacific Ocean for parasites. Results of this survey are compared with those of previously reported studies of parasites of O. bartrami from other areas and of other members of the family Ommastrephidae in the Pacific Ocean.

MATERIALS AND METHODS

Experimental fishing for flying squid was conducted from two vessels (Ocean Pearl and Tomi Maru #88) using drift gillnets between mid-June and early August 1987 (Jamieson and Heritage 1988). Although a total of 115 sets were made by both vessels, subsamples for parasitological examination were taken from only 5 sets (Table 1). The surface set nets were 10 m deep and surface water temperatures varied between 13.8 and 15.4°C. Because the majority of the flying squid caught were females, only female specimens were saved for parasitological examination. They were labelled with set numbers and each squid was placed in a plastic bag and frozen until examination about a year later.

Prior to examination, each squid was thawed overnight at 4°C. After examining the external surface (and plastic bag in which the squid was contained) for metazoan parasites, each squid was slit on the ventral midline. The gills, gonad, accessory digestive gland (pancreas), beak, and eyes were removed, each was placed in a separate Petri dish held at 4°C, and all were examined within 4 h. The digestive tract was removed (anterior section of the oesophagus was removed after opening the head along the dorsal midline) and placed on a white tray. The wall of the emptied mantle cavity was examined superficially. The digestive gland, on the tray with the rest of the digestive tract, was examined superficially and then discarded. Finally, the following preparations were

examined for helminths microscopically at 25X magnification: contents scraped separately from the oesophagus, stomach, pyloric caecum, diverticulum of the caecum, and intestine/rectum; the accessory digestive gland that was teased apart in distilled water; fluid and scrapings from the inside of the eyes; washings from the gonad; and the wall of the entire digestive tract, gills, and remainder of the gonad that was pressed between two clear acrylic plates (20 cm X 12 cm).

Free helminths from each organ were counted and preserved and all capsules (containing nematodes) associated with each organ were counted. All capsules on the mantle wall were opened and an attempt was made to remove all nematodes, which were counted and preserved. The number of nematodes in the capsules on the other organs were counted while these organs were being pressed between the acrylic plates. Most nematodes within capsules of the pressed organs, except for the stomach, were removed and preserved. Because of the abundance of capsules in the stomach wall and high numbers of nematodes within these capsules, only a subsample of a few nematodes from about half the capsules were preserved in 10% buffered formol saline for further study.

One third of the cestodes with an invaginated scolex and all acanthocephalans were stained with Semichon's acetic carmine (alcoholic) and mounted in Canada Balsam for detailed microscopic examination. All preserved nematodes were cleared in Langeron's lactophenol solution, mounted between a glass slide and coverslip and examined at 250X and 400X magnifications. After examination, the nematodes were transferred to a solution of 10% glycerin in 70% ethanol. Voucher specimens have been deposited in the Canadian Museum of Nature, Zoology Division, Ottawa, Ontario, Canada, with the following specimen numbers: CMN1990-0009 Tentacularia sp. (1 specimen), CMN1990-0010 Rhadinorhynchus sp. (1 male), CMN1990-0011 Rhadinorhynchus sp. (1 female and a fragment of a female) CMN1990-0012 to CMN1990-0017 Phyllobothrium sp. (6 specimens of varying size with scolex everted) CMN1990-0018 Phyllobothrium sp. (2 small specimens with scolex invaginated) CMN1990-0019 Anisakis simplex (11 specimens) CMN1990-0020 Hysterothylacium sp. (25 specimens from cysts on stomach wall), CMN1990-0021 Hysterothylacium sp. (25 specimens from cysts on gonad), CMN1990-0022 Hysterothylacium sp. (25 specimens free on surface of gonad), CMN1990-0023 Hysterothylacium sp. (25 specimens free in mantle cavity).

RESULTS

A total of 68 female flying squid (mantle length 38.7 ± 3.6 cm and total mean wet weight 2.1 ± 0.7 kg) were examined from the five drift gillnet sets (Table 1). The parasites recovered from the 12 squid from the Tomi Maru #88 (set 10)

were in poor condition, probably resulting from inadequate freezing. Nevertheless, the helminths could be identified and enumerated.

All flying squid examined were infected with larval nematodes (Table 2). A total of 3725 nematodes were counted in the 68 squid with an average of 54.6 nematodes per squid. Of the 3725 nematodes, 761 or 20.5% were preserved for examination. The bulk of the nematodes that were not preserved were found within capsules on the stomach wall containing more than one nematode per capsule.

Eleven of the preserved nematodes were Anisakis simplex larvae, with a maximum of two larvae per squid (Table 3). Ten A. simplex were encapsulated (one nematode per capsule) on the wall of the stomach and one was encapsulated on the gonad. Of the remaining 750 nematodes, 672 were identified as Hysterothylacium sp. Seventy-eight (10.4%) of the preserved nematodes were too badly damaged for precise identification, but they had features characteristic of the intact Hysterothylacium sp. The majority of the Hysterothylacium sp. (95.7%) was found within capsules on the stomach wall with an average of 3.3 ± 1.4 nematodes per capsule. Twenty-seven of the 68 flying squid had a total of 89 capsules on the mantle wall. Twenty of these capsules were empty and the remainder usually contained only one or two Hysterothylacium sp.

The Hysterothylacium sp. that were encapsulated on the stomach and gonad (96.5% of all Hysterothylacium with about 1% on the gonad) ranged in length from 2 to about 8 mm. However, the Hysterothylacium sp. that were encapsulated in the mantle or were free on the surface of the gills (approximately 2% of all specimens) ranged in length from about 20 to 35 mm. The remaining Hysterothylacium sp. (1.5%) that were free on the surfaces of the gonad, kidney, and caecum as well as free in the lumen of the stomach ranged in length from 4 to 25 mm.

Tetraphyllidean metacestodes were observed in 64 of the 68 flying squid with 1 to 22 (mean 6.4 ± 4.5) specimens in 63 of the squid and 121 small metacestodes (all less than 3 mm in length) in one squid. The scolex was everted in 374 of the 512 metacestodes and these were identified as Phyllobothrium sp. (probably P. caudatum (Zschokke and Heitz, 1914)). They varied from about 1 to 15 mm in length. Because 46 of the remaining 138 Tetraphyllidea that were stained, cleared, and mounted (to observe the morphology of the invaginated scolex) were also Phyllobothrium sp., all Tetraphyllidea from these squid were considered to belong to the same species. The majority of the Phyllobothrium sp. (96.9%) was recovered from the lumen of the digestive tract, with 0.2% in the lower oesophagus, 9.4% in the stomach, 44.2% in the pyloric caecum, 23.2% in the diverticulum of the caecum, and 19.9% in the intestine/rectum. The remainder were recovered from the surfaces of the gills (1.7%), digestive gland (0.4%), accessory digestive gland (0.2%), gonad (0.2%), and free in the body cavity (0.6%). One trypanorhynch metacestode of the genus Tentacularia (probably I. coryphaenae (Bosc, 1802)) was found free within the sample bag that held a squid from which the cestode presumably escaped.

Seven specimens of Acanthocephala were recovered from the digestive tract lumen of three squid. A group of five (four young females and one male) and a single male were within the bolus of partially digested fish in the stomach of two squid. One acanthocephalan (young female) was in the pyloric caecum of a third squid. Six of the seven Acanthocephala were sufficiently intact to be identified as Rhadinorhynchus sp. (either R. trachuri or R. cololabis, which are similar species and may be synonymous) and we presume the seventh specimen also belongs to the same species.

DISCUSSION

No major differences in helminth species and abundance were observed in the O. bartrami from the five sets examined during this investigation. Except for the Acanthocephala, no adult helminths were recovered. Other workers (Gaevskaya and Nigmatullin 1976, 1978; Naidenova 1978; Hochberg 1983; Naidenova et al. 1985) made similar observations on the rarity of mature helminths in Ommastrephidae and suggested that these squid acquire their helminth fauna (larval or juvenile forms that have a wide host range) from teleost fishes that occupy a similar ecological niche and constitute the diet of squid.

The larval Hysterothylacium sp. were identified generically by the almost spherical ventriculus, the presence of a ventricular appendage and intestinal caecum, and the excretory pore located at or near the level of the nerve ring. Specific identification of these nematodes was not attempted because of the uncertainty of the taxonomy and development of the larval stages of this group of nematodes from the Pacific Ocean. However, there was a great variation in the size (2 to 35 mm in length) of these larval nematodes. In general, the smaller Hysterothylacium sp. (about 6 mm in length) constituted the majority of the nematodes and they were mainly found within capsules in the stomach wall and on the gonad. The larger Hysterothylacium sp. (about 25 mm in length) were usually encapsulated in the mantle or free on the surface of the gills. Hysterothylacium sp. that were found free on various organs in the body cavity ranged in length between the two extremes noted above. This variation in size and site of occurrence may indicate that more than one species of Hysterothylacium were present and/or that these nematodes can undergo development and migration within the squid.

The high prevalence of Hysterothylacium sp. (100%) in flying squid in the northeastern Pacific Ocean suggests that O. bartrami may play an important role as a paratenic host in the life cycle of these nematodes in this area. Hysterothylacium sp. has also been recorded from O. bartrami in the northwestern Pacific Ocean but the prevalence (65% or less) was lower (Table 3). A closely related nematode (Contracaecum sp.) has also been reported from flying squid in the northwestern and southeastern Pacific and Indian oceans (Table 3). However, in the absence of information on the location of the excretory pore in these

nematodes it is not possible to know if they are truly members of the genus Contracaecum or belong to the more recently recognized related genus Hysterothylacium.

Anisakis species have been observed in most populations of Ommastrephidae that have been examined (Table 3). Anisakis physeteris (Anisakis type II larvae) is the predominant species of Anisakis in O. bartrami in the Atlantic Ocean whereas A. simplex predominates in the Pacific Ocean. Nevertheless, A. simplex has been observed in other Ommastrephidae (Todarodes sagittatus) in the North Atlantic (Berland 1961).

The low prevalence and intensity of Anisakis species in Ommastrephidae (except for Todarodes pacificus, Table 3) suggests that these squids are incidental hosts of this parasite on a global scale. Oshima (1972) indicated that the prevalence and intensity of A. simplex in T. pacificus vary with season. Apparently, the prevalence of infection is low in T. pacificus during the spring northward migration along the coast of Asia. However, there is a substantial increase in prevalence and intensity of infection between August and October when these squid are feeding in waters around Hokkaido (Oshima 1972). Anisakis simplex is believed to be responsible for most, if not all, human cases of anisakiasis (Smith and Wootton 1978). Because 8.5% to 37.5% of the A. simplex occurring in T. pacificus have been found in the mantle musculature, there is concern for the health of consumers of this commercial species of squid (Oshima 1972). The few A. simplex that were observed in O. bartrami during the present investigation were all found encapsulated on the viscera. Thus, they are not likely to cause human anisakiasis if the squid are either frozen or eviscerated soon after capture to prevent migration of the larvae into the mantle musculature.

Tetraphyllidean metacestodes have been reported from most samples of Ommastrephidae examined for parasites (Table 4). As in the present study, Phyllobothrium sp. seems to predominate in O. bartrami world wide. High prevalence and intensities of other tetraphyllideans, Dinobothrium sp. and Scolex pleuronectis, have been reported from other species of Ommastrephidae, Dosidicus gigas and Sthenoteuthis oualaniensis, from the southeastern Pacific Ocean (Table 4).

Although the majority of the Phyllobothrium sp. were recovered from the pyloric caecum during the present investigation, other specimens were found throughout the digestive tract as well as on the organs in the body and mantle cavities. Brown and Threlfall (1968) indicated that Phyllobothrium sp. are normally confined to the caecum of squid and that finding these metacestodes in other sites represents movement following host death. The recovery of Phyllobothrium sp. from various tissues in this investigation and the presence of some autolysis in many specimens suggests that the flying squid we examined were not frozen immediately after death.

The only other cestodes reported from flying squid are trypanorhynchan juveniles (Table 4). Unlike most other investigations, in which up to 25% of the flying squid were found to be infected with as many as 16 trypanorhynchan

metacestodes per squid, only one trypanorhynch, belonging to the genus Tentacularia, was observed during the present study.

No trematodes were found in the 68 O. bartrami examined during this study. However, trematodes of the family Didymozoidae are common in O. bartrami in the Atlantic, Indian and southeastern Pacific oceans (Table 4). They have been reported also in S. oualaniensis and D. gigas from the southeastern and subtropical northeastern Pacific Ocean and in a few (7.8%) O. bartrami from the northwestern Pacific Ocean (Table 4). The apparent absence of Didymozoidae in O. bartrami from the northeastern Pacific Ocean may be attributable to the large size of squid examined. Gaevskaya (1977) and Shukhgalter (1986) observed that didymozoid larvae are usually only present in smaller and younger squid that are intensively feeding on planktonic crustaceans and planktivorous fishes. The life span of didymozoid metacercariae rarely exceeds 4 to 6 months (Naidenova et al. 1985). Thus, the O. bartrami examined during this investigation may have already lost their infections if present at an earlier age.

Acanthocephala are relatively rare in Ommastrephidae. In addition to the seven adult specimens of Rhadinorhynchus sp. found during the present study, a few acanthocephalans have been reported from O. bartrami in the North Atlantic Ocean and northwestern Pacific Ocean (Gaevskaya and Nigmatullin 1976; Kurochkin and Solov'eva 1982). The presence of mature Acanthocephala in cephalopods is unusual because adults of this phylum typically parasitize only vertebrate hosts. It is possible that flying squid only serve as temporary hosts for these parasites, which apparently are acquired from the fish they consume. Saury, Cololabis saira, the host of Rhadinorhynchus cololabis in the northeastern Pacific (Baeva 1970; Arai 1989), is an important dietary component of flying squid (Jefferts 1986).

As evident from Tables 3 and 4, there is marked geographic variation in the parasite assemblages of O. bartrami. The parasite assemblages are similar in the North and South Atlantic but they differ from those in the North Pacific, with the parasite assemblages of flying squid from the Indian and southeastern Pacific oceans having some features of both the Atlantic and North Pacific oceans. For example, trematodes of the family Didymozoidae are abundant in the Atlantic, Indian, and southeastern Pacific oceans but infrequent in the North Pacific. Similarly, nematodes of the genus "Porrocaecum" (the taxonomic status of these nematodes needs to be varified) are common in the Atlantic, Indian, and southeastern Pacific oceans but have not been reported from the North Pacific Ocean. Superimposed on the distribution of this Didymozoidae - Porrocaecum assemblage is the presence of metacestodes of Nybelinia lingualis in the Atlantic and Indian oceans but not in the Pacific Ocean and the presence of the Hysterothylacium-Contracaecum complex of nematodes in the Pacific and Indian oceans but not in the Atlantic Ocean. Other differences can be noted in Tables 3 and 4. These broad geographic differences in parasite assemblages of O. bartrami, which have an ecological basis, do not parallel the results of genetic population analysis based on isoenzyme characteristics of cholinesterases from the visceral ganglion (Shevtsova et al. 1979). Using these isoenzyme characteristics, Shevtsova et al. (1979) were able to identify three separate

populations with ranges that encompassed: 1) the North Atlantic Ocean and the Mediterranean Sea, 2) the South Atlantic Ocean, Indian Ocean, and southwestern Pacific Ocean including the Coral and Tasmanian seas, and 3) the North Pacific Ocean. Nevertheless, electrophoresis, comparative morphology, and the presence of parasites has recently been used to distinguish two species of Nototodarus (Ommastrephidae) in New Zealand waters (Smith et al. 1981).

Comparison of our results with those of Bagrov (1982), Kurochkin and Solov'eva (1982), and Nagasawa and Nakata (1984) indicates the existence of a major difference between the helminth assemblages of O. bartrami from the northeastern and northwestern parts of the North Pacific Ocean (Table 4). Nybelinia surmenicola appears to be absent from the flying squid in the northeastern region whereas it is common in flying squid from the northwestern region. In addition, the prevalence of Hysterothylacium-Contracaecum is higher in flying squid from the northeastern North Pacific Ocean (Table 3). Future investigations into the taxonomy of these larval nematodes may reveal that more than one species is present (as indicated by the variation in size and site of encapsulation in the squid from the northeastern Pacific Ocean) and that species differences occur between O. bartrami populations from each side of the North Pacific Ocean. Nevertheless, the already identified difference in occurrence of N. surmenicola suggests that flying squid in the eastern and western parts of their northern range in the Pacific Ocean do not intermingle. Thus, these preliminary studies indicate that parasite assemblages may be useful to determine if eastern and western North Pacific flying squid intermix on their spawning grounds or remain segregated.

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TABLE 1. Bridge log data of the Canadian experimental drift gillnet fishery in 1987^a pertaining to flying squid, Ommastrephes bartrami, samples examined for parasites.

Set ^b number	Date	Starting location		Length of set (km)	Duration (hr.min)	Number of squid caught	Number examined
		N. lat.	W. long.				
03-OP	15/6	41°03'9"	130°27'6"	32.5	8.55	425	8
10-OP	22/6	45°09'3"	130°22'5"	32.5	9.05	3890	17
10-TM	24/6	45°31'7"	130°24'0"	49.0	10.45	3458 ^c	12
34-OP	21/7	47°26'3"	130°14'4"	28.7	8.05	2965	12
46-OP	02/8	48°23'8"	132°46'3"	28.6	8.55	5570	19

^aFor complete data see Jamieson and Heritage (1988).

^bSet numbers are followed by initials of the fishing vessels Ocean Pearl and Tomi Maru #88.

^cEstimated.

TABLE 2. Prevalence^a and intensity^b of parasites in flying squid, Ommastrephes bartrami, caught during an experimental flying squid fishery in the northeastern Pacific Ocean^c.

Parasites	Set number (sample size)				
	03-OP(8)	10-OP(17)	10-TM(12)	34-OP(12)	46-OP(19)
Nematoda ^d					
Nematodes in stomach					
Prevalence	100%	100%	100%	100%	100%
Intensity	67.9±33.6	66.5±35.5	28.3±17.7	37.0±22.2	57.7±29.4
Capsule intensity	16.4±4.2	17.5±6.9	14.3±5.8	12.8±5.1	15.8±6.9
Nematodes/capsule	4.0±1.2	3.7±1.2	2.1±1.1	2.7±1.0	3.9±1.6
Nematodes in gills and mantle					
Prevalence	62.5%	47.1%	33.3%	41.7%	36.8%
Intensity	1.5±0.5	5.5±6.1	3.0±2.4	1.9±0.8	3.0±1.5
Capsule intensity	2.8±2.9	5.7±5.9	3.0±2.4	2.0±0.8	2.0±1.2
Nematodes/capsule	0.7±0.4	0.9±0.3	1.0±0	0.7±0.3	1.0±0
Nematodes in other tissues					
Prevalence	37.5%	64.7%	33.3%	41.7%	57.9%
Intensity	3.0±0	2.2±1.4	1.0±0	1.4±0.9	3.1±1.9
Capsule intensity	1.3±0.6	1.2±0.4	1.0±0	1.0±0	1.1±0.3
Nematodes/capsule	2.1±0.8	1.3±0.7	1.0±0	3.0±0	2.5±1.4
Cestoda					
<u>Phyllobothrium</u> sp.					
Prevalence	100%	94.1%	100%	91.7%	89.5%
Intensity	7.8±4.0	7.1±5.8	8.0±5.6	4.5±2.9	11.8±28.2
<u>Tentacularia</u> sp.					
Prevalence	0	0	0	8.3%	0
Intensity	0	0	0	1.0±0	0
Acanthocephala					
<u>Rhadinorhynchus</u> sp.					
Prevalence	12.5%	0	0	16.7%	0
Intensity	5.0±0	0	0	1.0±0	0

^aNumber of squid infected with particular parasite divided by the number of squid examined and expressed as a percentage.

^bMean number of individual parasites per infected host in a sample $\pm$ standard deviation.

^cSee Table 1 for details of samples from the fishery.

^d761 of the 3725 nematodes were preserved and cleared for microscopic examination. 750 were Hysterothylacium sp. larvae and 11 were Anisakis simplex larvae.

TABLE 3. Nematoda reported^a in surveys of parasites of *Ommastrephes bartrami* from various oceans and in other species of the family Ommastrephidae (*Sthenoteuthis oualaniensis*, *Dosidicus gigas*, and *Todarodes pacificus*) from the Pacific Ocean.

Host (References)	Locality	<i>Contracaecum</i> ^b	<i>Hysterothylacium</i>	<i>Porrocaecum</i>	<i>Anisakis simplex</i> ^c	<i>Anisakis physeteris</i> ^d	<i>Anisakis</i> sp.
<i>O. bartrami</i> (Gaevskaya & Nigmatullin 1976, 1978)	North Atlantic	-	-	small 96(2-20) ^e large 50(1-7)	-	19.2(1-2)	-
<i>O. bartrami</i> (Gaevskaya & Nigmatullin 1976, 1978; Gaevskaya 1976)	South Atlantic	-	-	small 72(1-35) large 28.5(2-27) over all 96(1-57)	-	6.1(1)	-
<i>O. bartrami</i> ^f (Gaevskaya et al. 1986)	Southwestern Atlantic	-	-	42(1-2000)	5.7(1)	11(1)	-
<i>O. bartrami</i> ^g (Filippova 1974, Belyaeva 1979)	Indian	*	-	*	-	-	*
<i>O. bartrami</i> (Gaevskaya et al. 1983)	Southeastern Pacific	-	-	62(1-21)	-	-	*
<i>O. bartrami</i> (Shukhgalter & Polezhaev 1987)	Southeastern Pacific	43(12-104)	-	-	-	-	14(2)
<i>O. bartrami</i> ^h (Bagrov 1982)	Northwestern Pacific	13.5(*)	-	-	3(*)	0.8(*)	-
<i>O. bartrami</i> ⁱ (Kurochkin & Solov'eva 1982)	Northwestern Pacific	-	25.5(up to 13)	-	7.6(1-2)	*	-
<i>O. bartrami</i> (Nagasawa & Nakata 1984, Nagasawa pers. comm.)	Northwestern Pacific	-	64.3(*) ^j	-	*	-	-
<i>O. bartrami</i> (this report)	Northeastern Pacific	-	100(10-166)	-	13.2(1-2)	-	-
<i>S. oualaniensis</i> (Gaevskaya et al. 1983)	Southeastern Pacific	-	-	26.1(up to 30)	-	-	21(1-6)
<i>D. gigas</i> (Gaevskaya et al. 1982, 1983)	Southeastern Pacific	-	-	33-61.2(1-14)	-	-	5-32(1-5)
<i>D. gigas</i> ^k (Gaevskaya et al. 1987)	Central eastern Pacific	-	-	*	-	*	-
<i>T. pacificus</i> ^l (Kurochkin 1972)	Northwestern Pacific	-	-	-	0.6(1)	-	-
<i>T. pacificus</i> ^m (Bagrov 1982)	Northwestern Pacific	12.9(*)	-	-	2.2(*)	1.1(*)	-
<i>T. pacificus</i> (Shiraki 1974)	Northwestern Pacific	-	10.7-14.9 (mean 0.13-0.25)	-	15.6-25.2 (mean 0.30- 0.59)	1.0 (mean 0.01)	-

continued

Table 3. (continued)

^aData presented as prevalence with intensity in parenthesis; asterisks indicate quantitative data not provided and dashes (-) indicate parasite not reported.

^bMorphology of these nematodes not given, thus, they may either belong in this genus or to the more recently recognized Hysterothylacium.

^cA. simplex includes Anisakis larva reported as type I.

^dA. physeteris includes Anisakis larva reported as type II.

^e1500 small Porrocaecum were reported from one large squid (76 cm in length).

^fAlso reported Spinitectus sp. 3(4).

^gSpecific data not given, however, combined data for all larval nematodes was approximately 50% prevalence in Filippova (1974) and 30(1-11) in Belyaeva (1979).

^hIntensity of all nematodes (1-11) with total of 55 larval nematodes observed in 19 of 133 squid examined.

ⁱAdditional data presented as unidentified larval nematodes 26.7(1-95).

^jIntensity was indicated as numerous (usually more than 50-60 worms).

^kData not provided but indicated a change in prevalence and intensity of nematode infection with age of squid.

^lAlso reported Raphidascaris 0.4(1-3) and Acanthocheilus 0.2(1).

^mIntensity of all nematodes (1-4) with a total of 27 larval nematodes observed in 15 of 93 squid examined.

TABLE 4. Cestoda and Trematoda reported^a in surveys of parasites of Ommastrephes bartrami from various oceans and in other species of the family Ommastrephidae (Sthenoteuthis oualaniensis, Dosidiscus gigas, and Todarodes pacificus) from the Pacific Ocean^b.

Host (References)	Locality	Tetraphyllidea metacestodes	Trypanorhyncha metacestodes			Didymozoidae
			<u>Tentacularia</u> <u>coryphaenae</u>	<u>Nybelinia</u> <u>lingualis</u>	<u>Nybelinia</u> <u>surmenicola</u>	
<u>O. bartrami</u> (Gaevskaya & Nigmatullin 1976, 1978)	North Atlantic	1.9-4(2-7) ^c	5.7(1)	25(1-12)	-	40(hundreds)
<u>O. bartrami</u> (Gaevskaya & Nigmatullin 1976, 1978)	South Atlantic	2-3(1) ^c	19(1)	6.1(1)	-	36(hundreds)
<u>O. bartrami</u> (Gaevskaya et al. 1986)	Southwestern Atlantic	55.6(1-500) ^d 8(1-3) ^c	24(1-2)	28(1-2)	-	91.2(1-250)
<u>O. bartrami</u> (Belyaeva 1979)	Indian	-	20(1-10)	20(2-16)	-	100(1-several hundred)
<u>O. bartrami</u> (Gaevskaya et al. 1983)	Southeastern Pacific	* ^{c, e}	*	-	-	100(9-613)
<u>O. bartrami</u> (Shukhgalter & Polezhaev 1987)	Southeastern Pacific	14(12) ^d	-	-	-	86(6-1500)
<u>O. bartrami</u> (Kurochkin & Solov'eva 1982)	Northwestern Pacific	* ^{c, f}	-	-	40.4(up to 21)	7.8(1-70)
<u>O. bartrami</u> (Nagasawa & Nakata 1984)	Northwestern Pacific	*(common) ^g	-	-	*(high)	-
<u>O. bartrami</u> (this report)	Northeastern Pacific	94.1(1-121) ^c	1.5(1)	-	-	-
<u>S. oualaniensis</u> ^h (Gaevskaya et al. 1983)	Southeastern Pacific	26(10-25,000) ^e	*	-	-	* ⁱ
<u>S. oualaniensis</u> (Shukhgalter 1985, 1986)	Southeastern Pacific	*(up to 5,000) ^d 6.0(1-5) ^c	12.1(1-5)	-	-	22(1-30)
<u>D. gigas</u> (Gaevskaya et al. 1982)	Southeastern Pacific	2.9(1) ^c 44.6(10-25,000) ^e	23.8(1-4)	-	-	5(*)
<u>D. gigas</u> (Gaevskaya et al. 1983)	Southeastern Pacific	73(1-50,000) ^e	-	-	-	* ⁱ
<u>D. gigas</u> (Shukhgalter 1985, 1986)	Southeastern Pacific	1.1(1-5) ^c 66.5(up to 63,000) ^d	7.4(1-5)	-	-	13.7(1-30)
<u>D. gigas</u> (Gaevskaya et al. 1987)	Central eastern Pacific	* ^{c, d}	*	-	-	*
<u>T. pacificus</u> (Kurochkin 1972)	Northwestern Pacific	14.6(1-5) ^j	-	-	22.2(1-10)	-

continued

Table 4. (continued)

^aData presented as prevalence with intensity in parenthesis; asterisks indicate quantitative data not provided and dashes (-) indicate parasite not reported.

^bNot included in body of table are the following records:

- 1) Phyllobothrium sp. and Tetrarhynchus sp. metacestodes in D. gigas from subtropical northeastern Pacific (MacGinitie and MacGinitie 1949).
- 2) Phyllobothrium sp. and Pelichnibothrium speciosum in D. gigas from subtropical northeastern Pacific (Fields 1965).
- 3) Didymozoidae in S. oualaniensis, 33.3(140), from eastern tropical Pacific (Fields & Gauley 1972).
- 4) Didymozoidae frequent in small O. bartrami from Indian Ocean (Filippova 1974).
- 5) Didymozoidae in D. gigas, 71.4(1-15), from subtropical northeastern Pacific (Overstreet & Hochberg 1975).
- 6) Unidentified trematodes in 13.2% S. oualaniensis from northwestern Pacific (Okutani and Tung 1978).
- 7) Didymozoidae in O. bartrami, 100(9-1500), from southeastern Pacific (Shukhgaltier 1986).

^cIdentified as Phyllobothrium sp.

^dIdentified as Solex pleuronectis.

^eIdentified as Dinobothrium sp.

^fPrevalence and intensity included under category "larval cestodes" as 84.2 (up to 225).

^gIdentified as Phyllobothrium caudatum.

^hThe authors also identified one Trypanorhyncha from this host as Christianella(?) sp.

ⁱFor S. oualaniensis and D. gigas combined, 7.4(1-30).

^jIdentified as Pelichnibothrium speciosum (syn. Phyllobothrium caudatum)

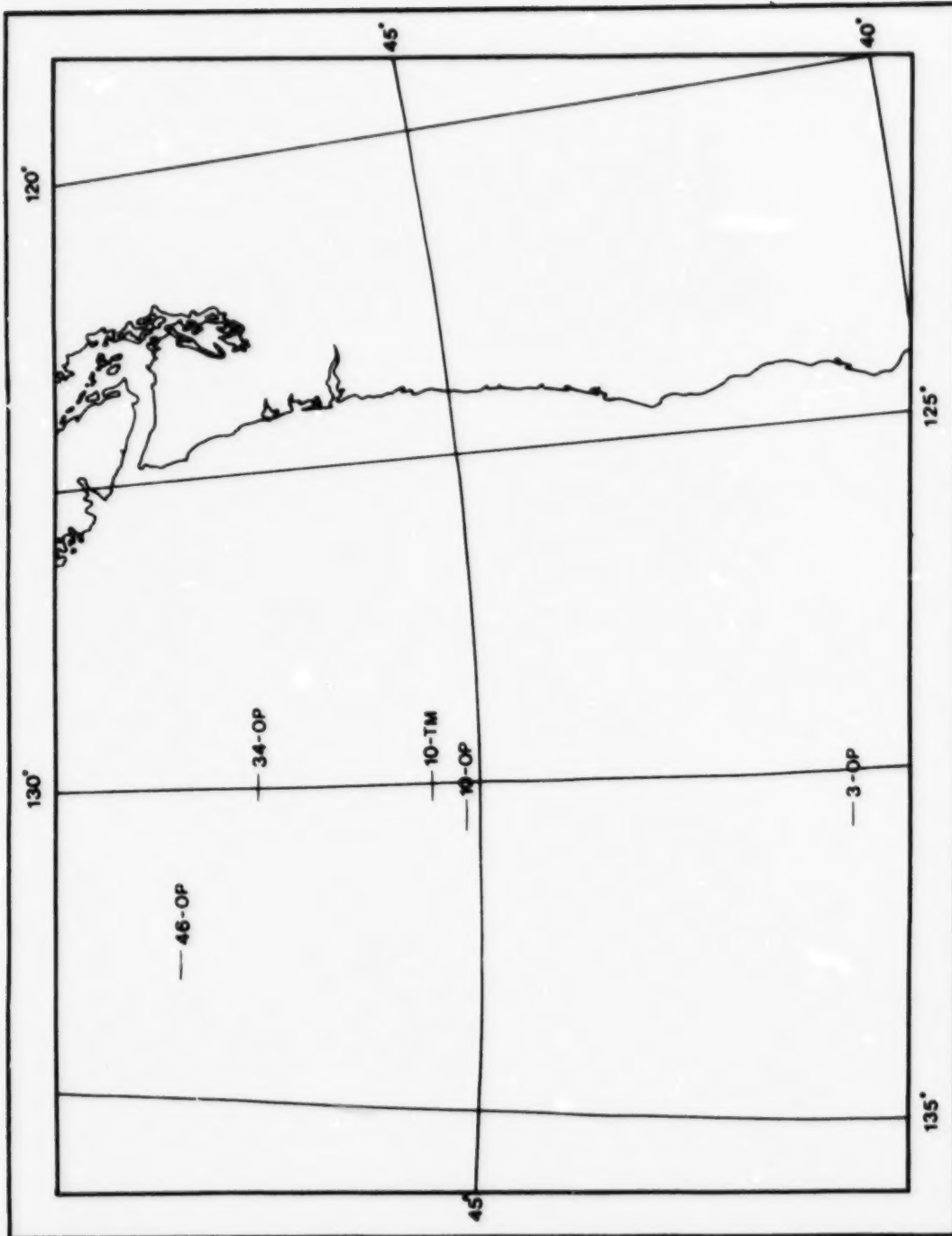


Fig. 1. Drift gillnet set locations in 1987 from which flying squid, *Ommastrephes bartrami*, samples were collected for parasitological examination.